bass taken in the Shiawassee river, the Upper Saginaw, at Corunna, Mich. About one-fourth of the fish taken had one or more of the parasites. They are taken occasionally from the Niagara at Buffalo. I have diligently sought for the male without, as yet, finding him.

EXPLANATION OF THE FIGURES.

Fig. 1. Dorsal view of female; *e*, ovisacs; *o*, ovaries; *a*, alimentary canal; *m*, mouth; at *x*, *y* and *z*, are the appendages shown in Fig. 2.

Fig. 2. Thoracic appendage; *a*, protopodite; *b*, exopodite; *c*, endopodite.

Fig. 3. Mouth; *a*, first pair of antennæ; *b*, second antennæ; *n*, mandibles; *f*, foot-jaws.

SOME OBSERVATIONS UPON THE DESTRUCTIVE POWERS OF CERTAIN INSECTS.

BY C. M. VORCE.

Almost every microscopist is familiar with that interesting object, the "*proventriculus*" or gizzard of the cricket, as well as the corresponding organ of the cockroach, and doubtless the first has impressed most observers with its appearance of destructive power; indeed, to view its hard, sharp, knife-like teeth or processes and its remarkably powerful compressor muscles, reminds the observer of the resistless force of the quartz crushing mill. The question at once suggests itself: what purpose is this highly developed organ designed to serve in the general economy of nature? Its specific object in the insect's organization is plainly to cut and crush, in fact to masticate, the food taken into the stomach. But the cricket is not commonly classed as a destructive insect and is rather considered harmless, and so far as economic ends are concerned it appears to be harmless.

These reflections invite comparison of the masticatory and digestive apparatus of the cricket with that of the notoriously destructive locust, or grasshopper, the cockroach, and other destructive insects.

Starting with the harmless cricket, we should expect to find its destructive relative, the locust, armed with a terrible enginery of destruction, but on examination this expectation is not realized. The gizzard of the grasshopper (*Caloptenus*) is weakly, armed with but a single circlet of inconspicuous teeth, short and blunt, seemingly capable of but little crushing or cutting action. Nearly the entire œsophagus, however, of the locust is set with rows of numerous small, sharp, thorn-like teeth, almost exactly the shape of pike's teeth, pointing backward, and underlaid by longitudinal muscles which are apparently capable of action independently of each other, thus giving exactly the feed motion of the sewing machine. Near the gizzard these teeth are set on separate chitinous plates, three to seven teeth on a plate. Nearer the mouth they are set in long rows on longitudinal chitinous ridges and are longer than those on the plates. These thorn-like teeth can, however, effect little, if any, comminution of the food, and so far as

masticatory power is concerned, the destructive locust seems but a weakling in comparison with the harmless cricket.

But to test this deduction by results we examine the contents of the intestinal canal which have passed the action of the gizzard, and here we find that the food of the locust has in fact undergone but little mastication. Large tracts of unaltered vegetable cells are found, and sometimes long uncoiled filaments of spiral tissue, with occasional veritable "chunks" of vegetable tissue, swallowed whole and remaining so. But the food of the cricket is found to be thoroughly masticated, very little of the contents of the intestine can be identified, and the greater part is completely amorphous. The same conditions are found to exist in each case in the voided excrement. The comparison extended to the cockroach (*Periplaneta*) shows that this voracious insect is also weakly armed for destruction, in comparison with the cricket, though much better provided than the locust. The gizzard of the cockroach, so well known, consists of six large pyramidal teeth, set in a circle, and covered with smaller teeth on the edge and sides, and when forced past each other by the strong muscles which surround them, they constitute a grinding apparatus on the same plan as the well known cornsheller and coffee mill, and fully justify the destructiveness attributed to their possessor.

The mole-cricket (*Gryllotalpa*), on account of his retiring disposition, is little known to most people, and consequently has not acquired what is called a "general reputation." Entomologists, however, credit him with some degree of destructiveness. Having unearthed him we find him provided with a well developed gizzard armed with six double rows of small blunt teeth, each placed on a larger chitinous plate, and each double row divided by a long, narrow, serrate edged chitinous plate, capable of a reciprocating longitudinal motion, thus forming a perfect saw. Each double row of gastric teeth with its median saw is separated from the adjoining rows by a deep furrow-like fold, in which the membrane seems very dilatable. Extending forward from each of the six rows of gastric teeth is a single row of six to eight flat, thin, chitinous teeth, fringed at the end with finger-like processes, giving each tooth exactly the outline of the familiar scale of the sole. These teeth in the mounted slide overlap each other like shingles, but in the natural state they stand up at a considerable angle. All the teeth in and out of the gizzard proper point backward in all of the insects examined.

The various species of grasshopper do not differ much in their masticatory apparatus. The common brown "flying grasshopper," as it is called, seems fully as well equipped in this respect as the dreaded Rocky Mountain locust (*Caloptenus spretus*), to investigate whose doings the government sent a "Locust Commission," at great expense but with good results. All our common species of grasshopper, if very numerous, might do immense damage, and judging from their great fecundity, as discovered in dissection, their increase is only kept within bounds by various parasites and other enemies, and by thorough cultivation.

The katydid (*Conocephalus*) has a gizzard more like that of the cricket than the others. It consists of six rows of large sharp-edged teeth, of a form difficult to describe without drawings, not notched like those of the cricket but lined on the edge and the front portion of the top with fine serratures, and infolding with a row of smaller sharp-edged teeth on each side, each compound row separated by serrate longitudinal bands of chitin. Each row of the large serrate teeth is preceded by a single row of six to ten broad, flat, overlapping teeth, each fringed with a row of bristles, which from the third tooth extends around the intervening two

teeth to the base of the first large tooth in the gizzard proper; from the third tooth (counting from the gizzard) these brush-like teeth rapidly diminish in size. Judging from this powerful apparatus we might expect the katydid to excel the locust and cockroach in destructiveness, but again we find its common reputation different from its apparent capabilities, as it is considered perfectly innocent of harm.

Reflecting upon what other factors may enter into the power of destruction, there seems but two necessary to be considered—the biting power and the digestive capacity, for it may be assumed that all the insects we are considering are blessed with equally good appetites, always ready for a meal and equally capable of seeking and finding it. Comparing then the biting apparatus of the same insects whose gizzards we have examined, we find them all well developed and powerful; evidently none of them lack power in this respect, but the locust may be given pre-eminence. His jaws, or mandibles, are broad, thick, deep-notched and sharp-edged, and a vertical section through the head shows that they are moved by heavy muscular bands attached to the sides and top of the large thick-walled head. It is no longer wonderful that he can so readily bite the hard, silicious stems of grass and straw, whose cuticles are found in his stomach. The well authenticated stories of crops eaten up in one day, seem not even singular in view of such biting power as we find the locust to possess. The mandibles of the katydid are nearly the same form, and those of the cricket nearly as powerful.

Now, turning attention to the matter of digestive power, we find again the locust better provided than any of the others. Surrounding the crop are six long blind sacs, opening into the stomach, each with a smaller sac opening at its base, and which communicate with a multitude of small but long secreting vessels or tubes, secreting a reddish liquid which is apparently the same as that so freely poured from the mouth of the locust when held captive in the hand, and which is doubtless in some degree both salivary and gastric, though this could only be satisfactorily determined by chemical tests. The corresponding vessels of the other insects are less extensively developed, and hence presumably less efficient, whence the conclusion seems to follow, that the crickets and mole-crickets bite and thoroughly masticate their food, exerting but a moderate digestive action upon it, and the cockroach bites and thoroughly masticates his food, at the same time effecting a more complete digestion of it, while the locust and katydid bite off and digest their food, to the extent of thoroughly softening it, with less mastication of it than the others, so that their food is more quickly passed off. And doubtless their great gastric development in some measure stimulates their desire for food and thus contributes to their ravenous habits, which their speedy disposal of food enables them to indulge. But the more complete destruction of their food by the crickets and cockroaches depends chiefly on the nature of their food, which consists of rotten or partly decayed vegetation, all of which being soft, simple mastication readily reduces, while the locust feeds upon growing vegetation containing much silica and woody fibre, which without thorough mastication resists the brief action of the gastric juice and passes off but little changed.

So that the answer to the query that we proposed to ourselves in the outset seems plainly this: The cricket passes his life in reducing animal and dead vegetable matter to a condition in which it may again enter the cycle of vegetable life, and being of comparatively limited digestive power, is by compensation gifted with extraordinary masticatory power, thus probably accomplishing as much to

this end as the grasshopper, whose work is not so completely done. The fact that the grasshopper is constantly in sight, and his work often carried to such excess as to be injurious to man, while the cricket is mostly unseen and his work pretty much unknown, has caused the one to be branded as man's destructive enemy, while the other is unthought of, although they are co-laborers in the same field, both literally and figuratively.

It is a point of some interest to find that the larva of a species of dragon-fly possesses a gizzard so strikingly like that of the cockroach that the chief difference seems to be that while the cockroach's gizzard has six teeth that of the dragon-fly larva has but four. Yet the food of this larva is soft-bodied larva and flies, and the crop often contains the entire eyes of small insects, in a condition suitable for immediate mounting in glycerine.

THE PREPARATION AND MOUNTING OF DOUBLE STAININGS.

BY C. C. MERRIMAN.

There is no art of the microscopist more beautiful and interesting than that of bleaching and re-coloring vegetable tissues. In no other way can the wonderful process of plant growth be made manifest under the microscope. Therefore, any suggestions tending to simplify the art and make it more generally practicable will be of interest to all workers in microscopic preparations. In my experiments with double staining I have found that different colors, or at least different pigments, vary greatly in the activity or penetrating power, with which they affect vegetable substances. Thus, an object prepared for staining may be left in a strong solution of carmine for a day without having all its parts colored; whereas in a log-wood or aniline dye of equal strength it would be colored perfectly opaque in less than an hour. By taking advantage of this fact and immersing objects first in the color having the slowest action, then in another of greater activity, and so on, double, or even multiple staining becomes a simple process, instead of the very difficult and complicated one which has been published in our magazines.

I will give the general details of the operation as I have now practised it for some little time. I do not claim that exactly the same formula will answer for all kinds of plant specimens, or that all the colors given below should be used in all cases. I merely give a general formula, which each operator will find it necessary to vary somewhat according to the results of his experimenting. If I succeed in stimulating others to more detailed work, by showing how simple the process is in most cases, I will have accomplished my purpose. All vegetable preparations, whether parts of leaves or sections of stems, should first be fully decolorized in the common chlorinated soda solution, sold by all druggists as a disinfectant. This result will be accomplished in most cases in about one day. Then, after being thoroughly washed in pure water, the preparations should be placed in a solution of carmine of about the consistence of common carmine ink; and they may remain in this for a day. Pure carmine will readily dissolve in water with a few drops of aqua ammonia in it. After being washed in two or three changes of pure